IT IS CLAIMED:

1. Apparatus for determining *in situ* a reflective characteristic of an area of a surface of an article being processed, comprising:

a machine component having a surface adapted to contact said article surface,

a window forming a portion of said component surface,

at least one source of optical radiation provided on the machine component on a side of the window opposite to the article contacting surface,

an optical radiation spreading element carried by the machine component between the window and said at least one source of optical radiation, said element spreading light from said at least one source of optical radiation through the window over an angle of 45 degrees or more,

collection optics carried by the machine component in a position to gather optical radiation passing through said window after reflection by the article area,

a photo-detector receiving optical radiation from the collection optics to generate a an electrical signal related thereto, and

a processor utilizing the electrical signal to determine the reflective characteristic of the article area.

2. The apparatus of claim 1, wherein the collection optics is characterized by gathering optical radiation through said window over an angle of 45 degrees or more.

3. The apparatus of claim 1, wherein the collection optics is characterized by gathering optical radiation through said window over an angle of 15 degrees or less.

4. The apparatus of claim 3, wherein the optical spreading element is characterized by spreading light through the window over an angle of 80 degrees or more.

5. The apparatus of claim 1, wherein the collection optics includes a first light pipe that extends through the spreading element with an end facing the window, and wherein the apparatus further includes a second light pipe having an end positioned between said at least one source of optical radiation and the spreading element to obtain optical radiation from said at least one source of optical radiation.

6. The apparatus of claim 5, wherein the article contacting surface of the component is planar and has a back surface defining a thickness of the element therebetween, and wherein all of the window, at least one source of optical radiation, the spreading element, the second optical radiation spreading element, the first light pipe end, and the second light pipe end are positioned in a compartment formed in the component between its said article contacting and back surfaces.

7. The apparatus of claim 5, additionally comprising a second optical radiation spreading element carried by the component between the window and said at least one source of optical radiation in a position to direct optical radiation from said at least one source of optical radiation into the second light pipe end.

8. The apparatus of claim 6, wherein an electronic unit is attached to said machine component that includes amplifiers for each of the first and second electrical signals, an analog-to-digital converting circuit, and a processor, an output of the processor providing data of the article area reflective characteristic being determined.

9. The apparatus of any one of claims 1-8, wherein the component is part of a chemical-mechanical-polishing machine that is given motion while processing the article area.

10. The apparatus of claim 9, wherein the component is a platen with a polishing pad as its said surface adapted to be contacted by said article.

11. The apparatus of claim 9, wherein the processor is characterized by providing an indication of an emissivity of the article surface area.

12. The apparatus of any one of claims 1-4, wherein at least two sources of optical radiation are provided at different optical wavelengths, the photo-detector receives optical radiation from the collection optics in said different optical wavelengths, and the processor utilizes signals from both of the optical wavelengths to calculate the article surface area reflective characteristic.

13. The apparatus of claim 12, additionally comprising circuits driving said at least two sources of optical radiation with different modulating frequencies, and electrical bandpass filters receiving the photo-detector signal to distinguish components modulated at said modulating frequencies.

14. The apparatus of claim 12, wherein the surface area reflective characteristic calculated by the processor is an indication of an emissivity of the article surface area.

15. The apparatus of claim 1, wherein said at least one source of optical radiation includes a plurality of radiation sources positioned across a reflective inside surface of a hemispherically shaped shell that opens onto said optical radiation spreading element.

16. A method of monitoring the processing of the surface of at least one article by chemical-mechanical-polishing wherein the article is held by a first machine surface in a manner that a surface of the article is urged against a second machine surface and relative motion is provided therebetween, comprising:

providing the first surface with a different reflective property than the surface of the article,

providing at least one sensor recessed into the second surface in a position to be scanned across said at least one article surface as the first and second surfaces move with respect to each other and provide an electrical signal related to a reflective property of the article surface and of the first surface there around as a function of the position of said at least one sensor thereacross,

detecting discontinuities in a level of the electrical signal that occur as the sensor passes across edges of the article,

using at least one of said signal discontinuities as a time reference to identify at least one segment of the electrical signal occurring between the signal edge discontinuities that corresponds to a region of the article whose surface is desired to be monitored during the processing,

accumulating data from repetitive occurrences of said signal segment as the sensor repetitively scans across the article surface, and

converting the accumulated signal segment data into a representation of the reflectivity or emissivity of the individual article surface throughout a period of the processing.

17. The method of claim 16, wherein two or more articles are simultaneously processed, thereby to generate a signal having discontinuities as the sensor passes across the edges of each of said two or more articles, at least one electrical signal segment being identified for each of the two or more articles, data being accumulated from repetitive occurrences of each of the individual article wafer segments and the accumulated data being converted into representations of the

reflectivity or emissivity of the individual article regions corresponding to the individual article signal segments.

18. The method of either of claims 16 or 17, additionally comprising illuminating the article surface with incident optical radiation spread over an angle of at least 45 degrees, and capturing by the sensor a portion of the incident optical radiation reflected by the article surface over an angle of 45 degrees or more.

19. An optical method of monitoring the thickness of a layer of transparent material carried by a substrate as it is being changed by processing, comprising:

acquiring data of an optical characteristic of the layer at at least first and second distinct wavelengths of optical radiation, wherein said optical characteristic varies differently as a function of the thickness of the layer at said first and second wavelengths,

maintaining a relationship of values of thickness of the layer as a function of pairs of values of the optical characteristic data at the first and second wavelengths, and

repetitively converting measured pairs of values of the optical characteristic at the respective first and second wavelengths to values of layer thickness by reference to said relationship, said converting occurring simultaneously with the processing changing the thickness of the layer.

20. The method of claim 19, wherein acquiring data of an optical characteristic of the layer includes illuminating the surface with optical radiation including said first and second wavelengths, receiving a portion of the illuminating radiation reflected from the layer, and detecting the reflected radiation in a manner to provide separate signals related to levels of the reflected radiation at said first and second wavelengths.

21. The method of claim 20, wherein detecting the reflected radiation includes providing first and second photodetectors in the path of the reflected radiation with respective first and second optical bandpass filters in front thereof, said first filter passing optical radiation of the first wavelength while blocking optical radiation of the second wavelength and the second filter passing optical radiation at the second wavelength while blocking optical radiation at the first wavelength.

22. The method of claim 20, wherein illuminating the surface includes modulating illuminating radiation of said first and second wavelengths at respective first and second distinct frequencies, and wherein detecting the reflected radiation includes obtaining a photodetector electrical output signal thereof and filtering said electrical signal to pass components thereof that are related to values of the optical signal at said first and second frequencies.

23. The method of claim 19, wherein the optical characteristic of the layer for which data is acquired includes an emissivity of the layer.

24. The method of claim 19, wherein maintaining the relationship of values includes maintaining a table of pairs of values of the optical characteristic at said at least first and second wavelengths for each of a plurality of thicknesses of said layer, and converting measured pairs of values of the optical characteristic to values of layer thickness includes looking up the layer thickness in this table.

25. The method of any one of claims 20-22, wherein illuminating the surface additionally includes directing the optical radiation against the surface over an angle of 45 degrees or more and receiving radiation reflected from the layer includes receiving said radiation over an angle of 45 degrees or more.

26. The method of claim 25, wherein the optical characteristic of the layer for which data is acquired includes a reflectivity of the layer.

27. The method of claim 25, wherein the optical characteristic of the layer for which data is acquired includes an emissivity of the layer

28. The method of any one of claims 19-23, wherein the processing being performed on said layer is chemical-mechanical-polishing.

29. A method of changing the thickness of a layer of metal carried by a substrate, comprising,:

directing optical radiation against the layer over an angle of at least 45 degrees, thereby to reflect a portion of said radiation from said layer, and receiving the reflected radiation over an angle of at least 45 degrees,

simultaneously processing the layer to alter its thickness,

monitoring the reflected radiation as the layer is being altered in thickness from a constant value over time until the value changes but before the value becomes constant over time at a different level,

comparing the value of the reflected radiation during its changing with known values as a function of the thickness of said layer, and

terminating altering the thickness of the layer when the reflected radiation is determined to correspond to the desired thickness of the layer.

30. The method according to claim 29, wherein the layer is being processed by CMP to remove material therefrom.

31. The method of forming metal lines on an integrated circuit structure, comprising:

forming a dielectric material layer over the integrated circuit structure,

forming trenches in a top surface of the dielectric material where metal lines are to be formed,

depositing a layer of metal material over the top surface and into the trenches of the dielectric material layer,

removing by a CMP process the metal layer from the top surface of the dielectric but not from the trenches,

concurrently with removing the metal layer, directing optical radiation against the integrated circuit structure with a spread of at least 45 degrees and receiving the reflected radiation,

monitoring the reflected radiation as the metal layer is being removed, and

terminating the CMP process when a discontinuity is noted in the level of the reflected radiation that corresponds to the metal layer being removed from the top surface of the dielectric.

32. The method of claim 31, wherein the integrated circuit structure being formed includes a plurality of circuit devices in which the metal lines are being formed arranged on a substrate with spaces between them in which no metal conductors are being formed, and further wherein the reflected radiation being monitored is reflected from said spaces between the circuit devices.

33. A method of measuring, through an optical radiation scattering medium, the thickness of a layer carried by a surface, comprising:

directing incident optical radiation through the scattering medium to the layer in a manner to obtain optical radiation reflected thereby, including spreading and scattering the optical radiation from one or more radiation sources prior to the incident radiation passing through the scattering medium,

capturing the optical radiation reflected by the layer through the radiation scattering medium over an angle sufficient to counteract effects of variations in scattering of the optical radiation by the radiation scattering medium,

capturing optical radiation from the one or more radiation sources without effect of the reflected optical radiation,

separately detecting the optical radiation reflected by the layer and the optical radiation from the one or more radiation sources, and

determining the thickness of the layer from levels of the detected optical radiation.

34. The method of claim 33, wherein spreading and scattering the optical radiation includes directing the incident optical radiation through a diffuser prior to striking the scattering medium and the layer.

35. The method of either one of claims 33 or 34, wherein directing optical radiation includes directing said optical radiation through the scattering medium to the layer over an angle of 45 degrees or more, and wherein capturing the optical radiation reflected by the layer includes receiving the optical radiation reflected by the layer through the scattering medium over an angle of 45 degrees or more.

36. A method of determining a particular characteristic of a surface area, comprising:

positioning at a first distance from the surface area an optical element that spreads incident optical radiation over an angle of 45 degrees or more,

directing optical radiation from one or more optical radiation sources to the radiation spreading optical element and thence onto the surface area to reflect the spread radiation from the surface area,

capturing, through the radiation spreading element, optical radiation reflected by the surface area with first radiation gathering optics having an angle of acceptance of 45 degrees or more and positioned a second distance from said surface area,

capturing optical radiation from the one or more radiation sources with second radiation gathering optics positioned to receive optical radiation from the one or more radiation sources,

detecting the optical radiation captured by the first and second radiation gathering optics, and

determining the particular characteristic of the surface area from levels of the detected optical radiation from each of the first and second radiation gathering optics.

37. The method of claim 36, wherein capturing optical radiation from the one or more radiation sources includes reflecting a portion of the optical radiation from said one or more radiation sources into the end of the second light pipe from a reflective optical radiation diffuser that is positioned in a path of optical radiation from said one or more optical radiation sources.

38. The method of claim 36, wherein the particular characteristic of the surface area includes its reflectivity, and determining the reflectivity includes taking a ratio of a detected level of optical radiation captured by the first and second light pipes.

39. The method of claim 36, wherein the particular characteristic of the surface area includes its emissivity, and determining the emissivity includes taking a ratio of a detected level of optical radiation captured by the first and second light pipes.

40. The method of claim 36, wherein the surface area extends across a film carried by a substrate, and the particular characteristic of the film being determined includes its thickness, and determining the film thickness includes comparing a detected level of optical radiation captured by the first and second light pipes.

41. The method of claim 36, wherein the surface area extends across a structure formed on a semiconductor wafer.

42. The method of claim 36, wherein the surface area extends across a structure formed on a flat panel display.

43. The method of any one of claims 38-42, wherein the particular characteristic of the surface area is being determined simultaneously with the surface area being processed in a manner that changes its said particular characteristic.

44. The method of claim 43, wherein the surface area is being processed by chemical-mechanical-polishing.

45. The method of any one of claims 36-42, wherein positioning the radiation spreading optical element includes positioning a transparent radiation diffuser the first distance from the surface area.

46. The method of claim 45, which additionally comprises holding said surface area against a moving element surface, and wherein directing radiation onto the surface area includes directing radiation from the one or more radiation sources and through the diffuser that are located within the moving element.

47. The method of any one of claims 36-42, wherein positioning the radiation spreading optical element includes positioning a hemispherical element having a plurality of optical radiation sources held around an inside surface thereof, which inside surface is reflective and positioned to open onto the surface area.

48. The method of any one of claims 36-42, wherein directing optical radiation to the radiation spreading optical element from one or more optical radiation sources includes directing said radiation from at least one source of optical radiation of a first bandwidth and at least one source of optical radiation of a second bandwidth, said first and second bandwidths being distinct from each other.

49. The method of claim 48, wherein the sources of optical radiation of the first bandwidth are driven at a first modulating frequency, the sources of optical radiation of the second bandwidth are driven at a second modulating frequency that is distinct from the first modulating frequency, wherein detecting the optical radiation includes directing the optical radiation captured by the first radiation gathering optics onto a photodetector, and wherein determining the surface area characteristic includes directing an electrical output signal from the photodetector through bandpass filters that respectively pass said first and second modulating frequencies.

50. The method of claim 40, wherein directing optical radiation to the radiation spreading optical element includes directing said radiation from at least one source of optical radiation of a first bandwidth and at least one source of optical radiation of a second bandwidth, said first and second bandwidths being distinct from each other, wherein the film is transparent to the optical radiation of said first and second bandwidths, and additionally comprising:

maintaining a relationship of values of thickness of the film as a function of pairs of values of the optical characteristic data at the first and second bandwidths, and

repetitively converting measured pairs of values of the optical characteristic at the respective first and second bandwidths to values of layer thickness by reference to said relationship.

51. The method of claim 40, wherein the film is metal, and additionally comprising:

maintaining a relationship of values of thickness of the film as a function of either reflectivity or emissivity in a region where the metal film becomes partially transparent to the optical radiation form said one or more optical radiation sources, and

repetitively converting measured pairs of values of the optical characteristic at the respective first and second bandwidths to values of layer thickness by reference to said relationship.

52. The method of either of claim 50 or 51, wherein the layer characteristic determining steps are performed simultaneously with the film being reduced in thickness by a process of chemical-mechanical-polishing.

53. The method of any one of claims 36-42, wherein directing optical radiation to the radiation spreading optical element includes modulating the optical radiation from said one or more optical radiation sources at a given frequency, wherein detecting the optical radiation includes directing the optical radiation captured by the first radiation gathering optics onto a photodetector, and wherein determining the surface area characteristic includes directing an electrical output signal from the photodetector through a bandpass filter that passes said given modulating frequency.

54. The method of any one of claims 36-42, additionally comprising repetitively moving across the surface the area to which optical radiation is directed from said one or more optical radiation sources and from which optical radiation reflected therefrom is captured, noting a change in the detected optical radiation caused by a discontinuity on the surface, and referencing a region on the surface in a certain position with respect to the discontinuity for which said particular surface area characteristic is determined.

55. The method of any one of claims 36-42, wherein capturing optical radiation reflected by the surface area by the first radiation gathering optics includes positioning an end of a first light pipe the second distance from the surface area.

56. The method of claim 55, wherein capturing optical radiation from the one or more radiation sources includes positioning an end of a second light pipe to receive optical radiation from the one or more radiation sources.